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AS AD NO.

ASD TR '7-904 (VI)

ASD INTERIM REPORT 7-904 (VI)
December 1962

STRUCTURAL FABRIC PROGRAM

J. O. Miller
E. Bilsky

GOODYEAR AIRCRAFT CORPORATION
Akron 15, Ohio

Contract: AF33(600)43036
ASD Project: 7-904

Interim Technical Progress Report
1 October to 31 December 1962

The purpose of this program, as related to aerospace applications, is to provide a means of manufacturing large low-density AIRMAT structures made of metallic cloth and yarns capable of small volume packaging.

METHODS AND MATERIALS DIVISION
MANUFACTURING METHODS DIVISION

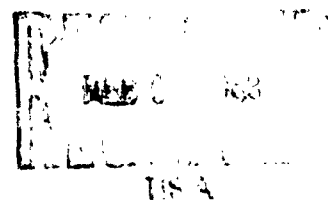
Aeronautical Systems Division
United States Air Force
Wright-Patterson Air Force Base, Ohio



GOODYEAR AIRCRAFT CORPORATION

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ABSTRACT - Summary

ASD Interim Report 7-904 (VI)

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J. O. Miller

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Goodyear Aircraft Corporation

The purpose of this program, as related to aerospace application, is to provide a means of manufacturing large low-density AIRMAT* structures made of metallic cloth and yarns capable of small volume packaging.

The work reported herein was accomplished during the sixth quarterly period under contract AF33(600)-43036. During this period the design and fabrication of the loom was continued and the design of the horizontal take-off mechanism was initiated.

The aforementioned efforts are directed toward the development of a loom procurement specification and the actual procurement of a loom capable of producing a low-density AIRMAT in the order of 20 feet wide with a maximum depth of 8 feet.

*T.M. - Goodyear Tire and Rubber Company

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FOREWORD

This Interim Technical Progress Report covers the work performed under Contract AF33(600)-43036 from 1 October to 31 December 1962. It is published for technical information only and does not necessarily represent the recommendations, conclusions, or approval of the Air Force.

This contract with Goodyear Aircraft Corporation was initiated under ASD Manufacturing Methods Project 7-904 "Structural Fabric Program". It is administered under the direction of Mr. J. O. Snyder, ASRCFT, of Methods and Materials Division, Aeronautical Systems Division, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio. This report is the sixth in a series to be published quarterly for the duration of the contract.

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SECTION I - INTRODUCTION

The glide re-entry vehicles presently being designed require large low-density structures. The use of fabrics for the structural material not only answers this requirement but provides the advantage of being pack-ageable in a small volume for ease of storage and handling on the ground with the additional advantages of maximum utilization of missile payload volume and minimum effect on the aerodynamic performance of the missile during ascent. The rapid pace of development in the astronautics field imposes the requirement that facilities, capable of producing quantities of fabrics for re-entry applications, be available in the near future. Goodyear Aircraft Corporation (GAC) is now engaged in a program under Contract AF33(600)-43036 to develop a loom and associated machinery and processes capable of producing metallic AIRMAT fabrics of such size, quality, and shape as required for re-entry vehicle applications. This report concerns itself with the effort during the sixth quarterly period under Contract No. AF33(600)-43036.

The ultimate objective of this program is a loom having the capabilities of weaving large AIRMAT structures. These capabilities will be demonstrated by weaving AIRMAT specimens in two (2) categories.

1. Type 304 stainless steel flat AIRMAT, 11 feet wide, 8 feet thick by 5' long (warp direction), 100 picks by 100 ends per inch.
2. Type 304 stainless steel contoured AIRMAT, 20 feet wide and 10 feet long with a cross section along the 20 foot fill direction consisting of 6 foot straight AIRMAT, 4 feet deep with the remaining 14 feet having an upper and lower parabolic contour tapering from 4 feet to 6 inches in depth. This specimen will have a 20% slope along the 10 foot length (warpwise). The specimen will have 100 picks by 100 ends per inch.

It is also intended that the loom shall have the capability of weaving shapes such as open end tubes, cones of different angles and curved surfaces of different radii of curvature such as ellipses and parabolas.

SECTION II - DISCUSSION

A. Work Completed During the Sixth Reporting Period

1. General Loom Design

The design of the basic loom is now essentially complete with parts procurement and fabrication currently underway. Approximately fifty percent of the detail drawings for the Structural Fabric Loom, except for the take-off mechanism, are now complete. A number of design changes were made during this period to increase the versatility of the loom. These design changes will be discussed in detail in subsequent paragraphs covering the individual design areas. In addition to the design changes on the loom itself, a change in the demonstration fabric specimens has been proposed which will eliminate the need for a spare set of beams, spare reed and a spare set of harnesses since it is proposed to weave both the flat and contoured specimen from the same stainless steel warp wire yarn rather than change warps from Rene' 41 to stainless steel during the weaving trials. Considerable savings in material and loom set-up costs are effected without reducing the loom demonstration.

2. Jacquard Mechanism

The Thomas Halton Sons Company are currently building four Jacquard machines capable of controlling 652 ends per machine. These Jacquard machines will be capable of three or four position weaving. It is noteworthy that no known four (4) position Jacquards are now in existence, thus the development of the four (4) position Jacquard represents an advance in the state-of-the-art. Two (2) of the four Jacquard machines will be driven from each side of the loom with provisions for adjusting the timing of the Jacquard operation with the basic loom cycles. Space will also be provided to increase the number of Jacquards from 4 units to 7 units should the requirement arise. Delivery of the first Jacquard unit is expected the end of January 1963.

3. Dobby Mechanism

The design of the Dobby has been completed and parts are being fabricated. The Dobby will be provided with gears and levers sufficient to activate 18 harness frames and will have a total capability of 24 harness frames by the addition of the necessary operating gears and levers. This additional capability is provided to enhance the versatility of the loom for future weaving programs.

The Dobby mechanism will be capable of either a two (2), three (3) or four (4) position operation and also represents an advance in the state-of-the-art.

4. Creels

The creel design is complete. Each creel frame will have a capacity of 400 spools. Seven creel frames will be provided with the loom complete with stop motions and yarn tensioning arrangements.

Yarn delivery from the creels will be accomplished tangentially from the spool since overhead delivery from the spools will cause twist insertion in the yarn which could cause wire weaving problems.

Yarn tensioning will be done by means of hanging specially designed weights on the yarn at several locations along the yarn path depending on the amount of tension required. Conventional post and disc type tensioning arrangements have been rejected because of the possibility of cold working the wire yarn using such a system.

5. Let-Off Mechanism

The let-off mechanism is currently being detailed. The let-off is a positive type which will be adjustable to match the let-off rate with the rate of take-up within reasonable limits.

Each of the four main beam sections is advanced in let-off by an amount dictated by the eccentric position on a crank disk. The amount of eccentricity is adjusted by means of

screws. Although these screws cannot be expected to be as sensitive as the counters on the take-off, the jumboes can absorb considerable error before a re-setting would be necessary.

Loom stop-motion systems will be incorporated into the let-off motion which will provide a means for stopping the loom should the loom let-off be improperly set and warp tension becomes excessive. Under such conditions the let-off weight lever arm will gradually change position from the normal horizontal position and engage the stop motion thus stopping the loom and signaling the operator to make a let-off adjustment.

6. Lay Motion

A $20^\circ - \frac{1}{4}$ inch double beat reed stroke will be incorporated to assist in controlling the weft shot at beat-up while the harness frames are crossing over. With this method, the maximum loom speed will be reduced by approximately 10%. The complete lay motion cycle will be as follows:

65°	-	10"	Forward reed stroke
10°	-	$\frac{1}{4}$ "	Rearward reed stroke
10°	-	$\frac{1}{4}$ "	Forward reed stroke
65°	-	10"	Rearward reed stroke
210°			Reed dwell in rear position

The double beat system has been included to insure that a higher number of picks can be woven into the fabric. The system is being designed such that single beat cams can be installed should the need arise.

7. Loom Drive

One of the areas of design change as previously mentioned is in the loom drive. It was decided to eliminate the variable speed drive units and replace them with constant speed motors and drive pulleys of different diameters to effect changes in speed. Two sets of driving components, one on each side of the loom, will be provided as noted in detail on the following page.

Loom Drive

- a. $7\frac{1}{2}$ HP 1750 rpm induction motor supplied with 5 different V-belt pulleys.
- b. No. K-12 Cycledyne electro-magnetic clutch and brake unit equipped with 20 inch P.D. V-belt pulley on input shaft driven by motor pulley.
- c. 4.167 inch P.D. or 8.250 inch P.D. gears mounted on output shaft of clutch-brake unit driving 15.833 inch P.D. or 11.750 inch P.D. gears mounted on input shaft reducer unit below.
- d. 20.48 to 1 ratio Foote Bros. speed reducer unit driven by gear sets listed above.
- e. 8 inch P.D. gear mounted on output shaft of reducer unit driving 12 inch P.D. gear on loom main drive shaft.
- f. Input or high speed shafts of reducer units on each end of loom coupled together with traverse shaft.
- g. The loom speeds available with the pulleys and gear sets supplied with the loom are listed below:

Motor Pulley Diameter	Gear Sets	
	4.167" & 15.833"	8.250" & 11.750"
3.6 Inches	2.7 ppm	7.2 ppm
4.0 Inches	3.0 ppm	8.0 ppm
5.0 Inches	3.75 ppm	10.0 ppm
6.0 Inches	4.5 ppm	12.0 ppm
7.0 Inches	5.25 ppm	14.0 ppm
8.0 Inches	6.0 ppm	16.0 ppm

8. Drop Yarn Extension Mechanism

Layout and design effort is now being concentrated on the pile extension pile delivery and the pile wire inserter.

drive assemblies. The pile wire will be pushed into the shed by a hopper slide type inserter driven by an oscillating cable drum actuated by a rotating crank adjustable in stroke for various width weaves. The inserter will be located on the left side of the loom. It is proposed to design a hopper capable of holding a minimum of 10 pile wires for consecutive insertions before reloading. The pile wire will have a size of .093" x .375" x 21' approximately. The back side of the wire will be serrated eliminating slippage of the movable gages. The front surface will be covered with a material, probably looped nylon tape, for reducing pile yarn slippage during extension. The wire will be of a corrosion resistant metal and contain a head on one end, similar to the pile wires used in making pile fabrics, for positive control for insertion. A series of wire lengths will be required to handle the range of fabric widths.

It is proposed to drive this mechanism from an independent source of variable speed power to provide for adjustments to obtain optimum performance of the mechanical extension mechanisms during start-ups and during weaving trials.

Two pile wire pressure plates, one for each side of the Loom, will be provided for use with the pile extension wire holding racks. The pressure plates on the left hand side of the Loom will be stationary and the right side will be adjustable.

Both a left hand and right hand mechanism will be provided for holding the pile wires and moving them along the pressure plates at the same rate that the fabric will be woven. The exact method of placing the bars into a slot or similar retaining device has not yet been established. The racks will be driven from the draw bars on the Loom take-off.

a. Movable Gages

These gages will have a maximum travel of 48 inches (to produce 96 inch AIRMAT) and an additional 10-12 inches to handle the travel the gage must make from the reed to the fell of the cloth.

The gages will be located across the Loom on 4 inch centers. The gages will be .011-.013 inches thick by 1-3/4 inch high by 9 feet long and will be made from stainless steel. The shape of the gages has not yet been firmly established but will approximate the improved design used on the GAC Experimental Loom.

Two dummy heddle frames, one behind the reed and the other located to the rear of the harnesses, will be provided for holding the movable gages. Either or both of these frames will be used, as required.

Retraction of the movable gages will be accomplished by means of a pulley and weight system located at the rear of the Loom in front of the bottom warp beam.

b. Fixed Gages

One fixed gage for each movable gage is being contemplated. This gage is to be constructed of 7/16 inch O.D. by 20 gage wall, steel tubing flattened for 8 feet in front of the weaving edge. Two flat gages .011 inch thick by 1/2 inch high (302 S.S.) will be brazed to the tubing on the flattened end extending through the reed and heddles to attachment at the rear of the Loom. The attachment at the front end will be adjustable for tensioning these gages. It is planned to pass the cable wire through the tube of the stationary gages to eliminate any direct contact between the pile yarn and the moving cables.

c. Programming Mechanism

A mechanism for programming the amount of travel of the movable gages in the extension mechanism which determines the contour and heights of the AIRMAT is currently under consideration. The programmer utilizes a small scale profile model of the desired AIRMAT specimen with a profile tracing system to control the amount of pile displacement which in turn determines the depths and contours of the finished AIRMAT Specimens.

9. AIRMAT Specimens

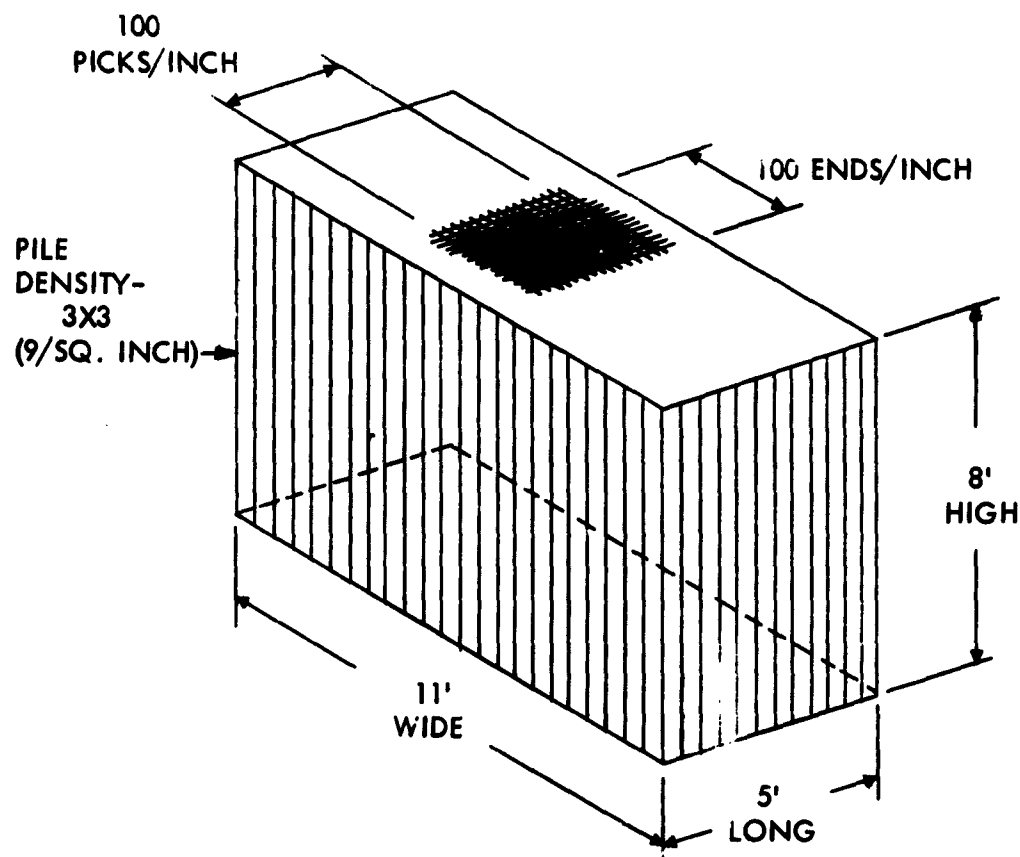
As noted on Page 1, two (2) specimens are to be woven as part of the Structural Fabric Program. The configuration and construction of these two specimens have been revised as noted on Page 1 and Figures 1 and 2. The newly proposed specimens will be entirely suitable to demonstrate the capabilities of the Structural Fabric Loom at considerably less cost and time than would have been required for the specimens previously proposed.

10. Weaving Techniques

During this quarter, much of the output of the GAC experimental loom was devoted to stainless steel wire plain cloth and AIRMAT. During this time much was learned with regard to weaving tensions and fabric design as related to wire fabric construction which will prove beneficial to the design and operation of the Structural Fabric Loom.

As a result of studies conducted during the above mentioned weaving program and after a thorough evaluation of the Structural Fabric Loom specifications and other design data, it is believed that the Structural Fabric Loom will have metal weaving capabilities as shown in Table 1. Although the Structural Fabric Loom is specifically being designed to weave metal yarns it is believed that it will also successfully weave textile yarns. The range of yarn sizes, widths, lengths, etc. shown in Table 1 for wire yarns are applicable to textile yarns also.

The major problem in adapting this loom to textile weaving is the type filling inserting mechanism that will be used on the loom. This mechanism does not provide for a fabric selvage which could cause some unraveling of the textile warp yarn at the fabric edges. This is not a serious problem with wire yarns. Means for overcoming this problem with textile yarns can be accomplished with the use of a special weave (leno) at the fabric edges to help lock these ends in place. Also, the Structural Fabric Loom is being designed such that it will be possible to modify the filling inserters for incorporation of another type filling inserter which will provide a selvage.



MATERIAL

WARP - .003" DIA. TYPE 304 STAINLESS STEEL
 FILLING - .003" DIA. TYPE 304 STAINLESS STEEL
 PILE - .003" DIA. TYPE 304 STAINLESS STEEL

FIGURE 1
FLAT AIRMAT SPECIMEN

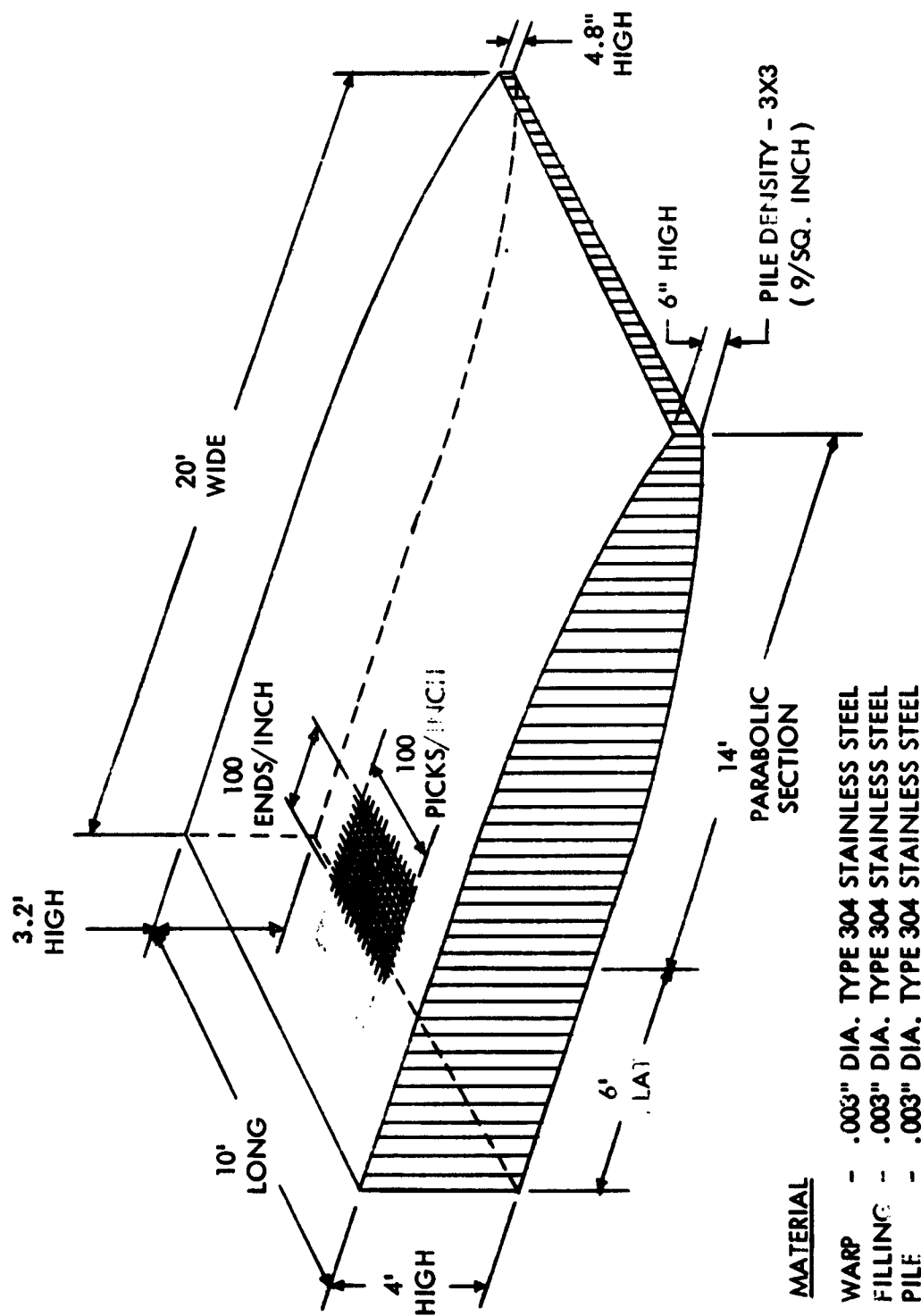


FIGURE 2
CONTOURED AIRMAT SPECIMEN

Figure 3 shows three (3) inch stainless steel AIRMAT being woven on the GAC experimental loom. The final dimensions of the AIRMAT shown on the take-off mechanism in Figure are 5 feet by 14 feet.

TABLE 1
STRUCTURAL FABRIC LOOM
WEAVING CAPABILITIES

<u>Metal AIRMAT</u> <u>(Flat or Contoured)</u>	<u>Explanation</u>
a. Pile Height Max 96" Min 2" (approx)	Limited by design of extension mechanism. Increased heights possible but will require equipment changes. Lower pile heights possible when weaving flat AIRMAT w/o extension mechanism.
b. Fabric Width Max 21' Min 3'	Usable width will be approximately 20'. Smaller widths than 3' possible but not considered practical on such wide equipment.
c. Unit Length Max 35'	Limited by length of take-off and length of extension mechanism gages.
d. Wire Yarn Sizes (dia) Max .032" Min .0015"	Includes either mono or multifilament yarns.
e. Fabric Construction Max 200 x 200	Higher constructions possible and depends on yarn size and weave.
f. Type of Weave	All varieties of plain, twill or sateen weaves within a 9 harness capability. Can be increased to a 12 harness capability with purchase of additional parts.
g. Pile Density Max 40 ends/in ²	10 ends across width and 4 ends along warp will be possible using mechanical extension system. Higher pile density (60-70/in ²) possible w/o extension mechanism.

TABLE 1 (Cont.)

<u>Metal AIRMAT</u> <u>(Flat or Contoured)</u>	<u>Explanation</u>
h. Loom Speed Max 16 picks/min Min 2.7 picks/min	Selection of speed is dependent on size of yarn and fabric width. A general operating speed of 10 picks/min. is contemplated.

11. Take-Off Mechanism

The take-off mechanism design has been finalized as shown in Figure 4. The complete mechanism consists of a support structure containing side rails on which in turn are mounted the service platform, draw bar mechanism carrier tables and the drop yarn extension programmer.

a. Service Platform

The service platform is roller mounted on the two side rails and is so constructed to straddle the draw bar, carrier tables and programmer thus permitting complete access to all areas of the take-off during weaving. In its position closest to the front of the loom, the platform will be used when tying-in and when adjusting the Jacquard heddles.

b. Draw-Bar Mechanism

The draw-bar mechanism will be constructed to have a total travel of 60 feet with a position closest to the weaving edge of 13 inches for tie on. A schematic diagram of the draw-bar drive is shown in Figure 5.

c. Carrier Tables

The carrier tables are suspended between the two side rails on rollers which run on the side rail lower flanges. The tables are provided to support the woven AIRMAT and to provide support for extension mechanism pile wires.

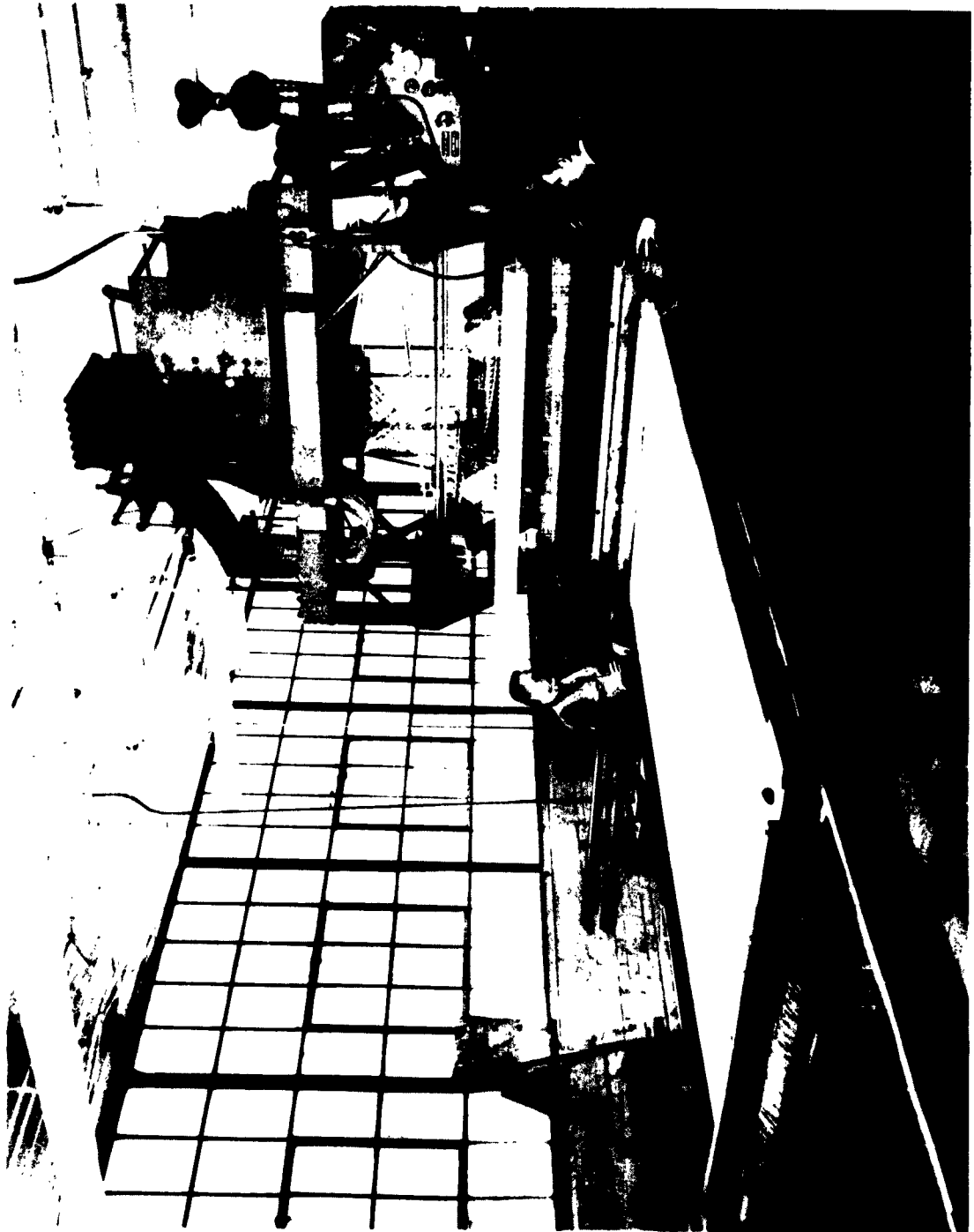
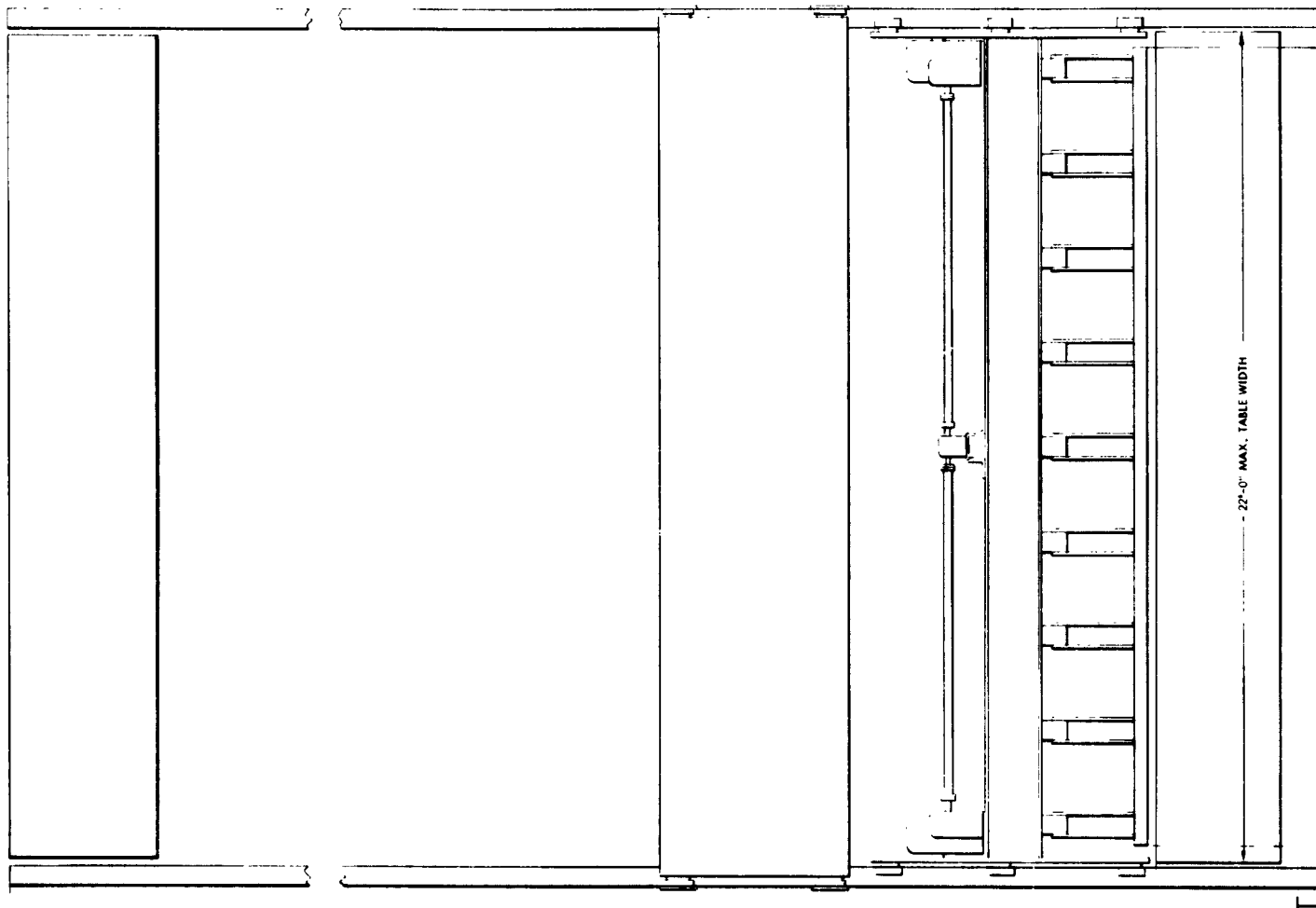


FIGURE 3
3" STAINLESS STEEL AIRMAT

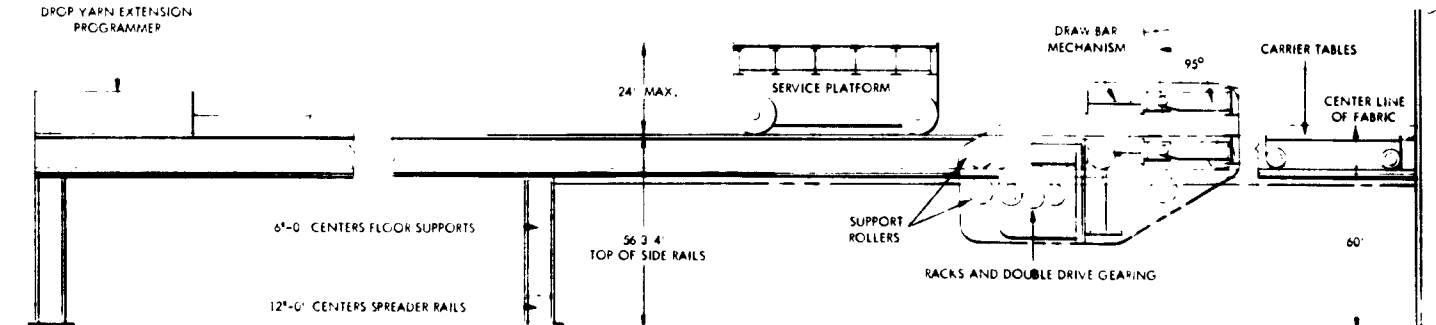
1



60'-0" MAX. TRAVEL

70'-0" TRAVEL

DROP YARN EXTENSION
PROGRAMMER



TAKE OFF MECHANISM - 252 FABRIC LOOM
COMPOSITE SIDE ELEVATION AND PLAN

2

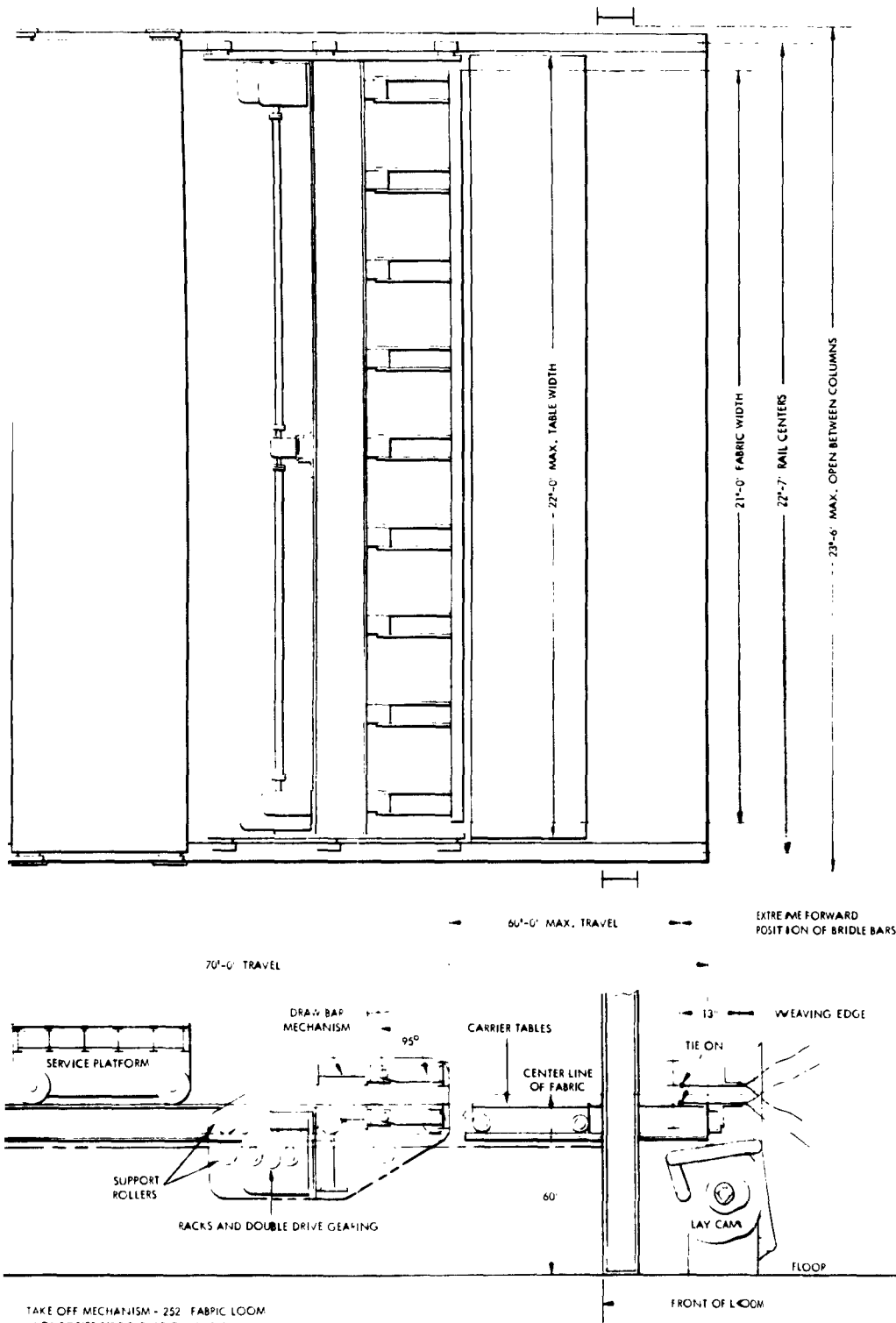
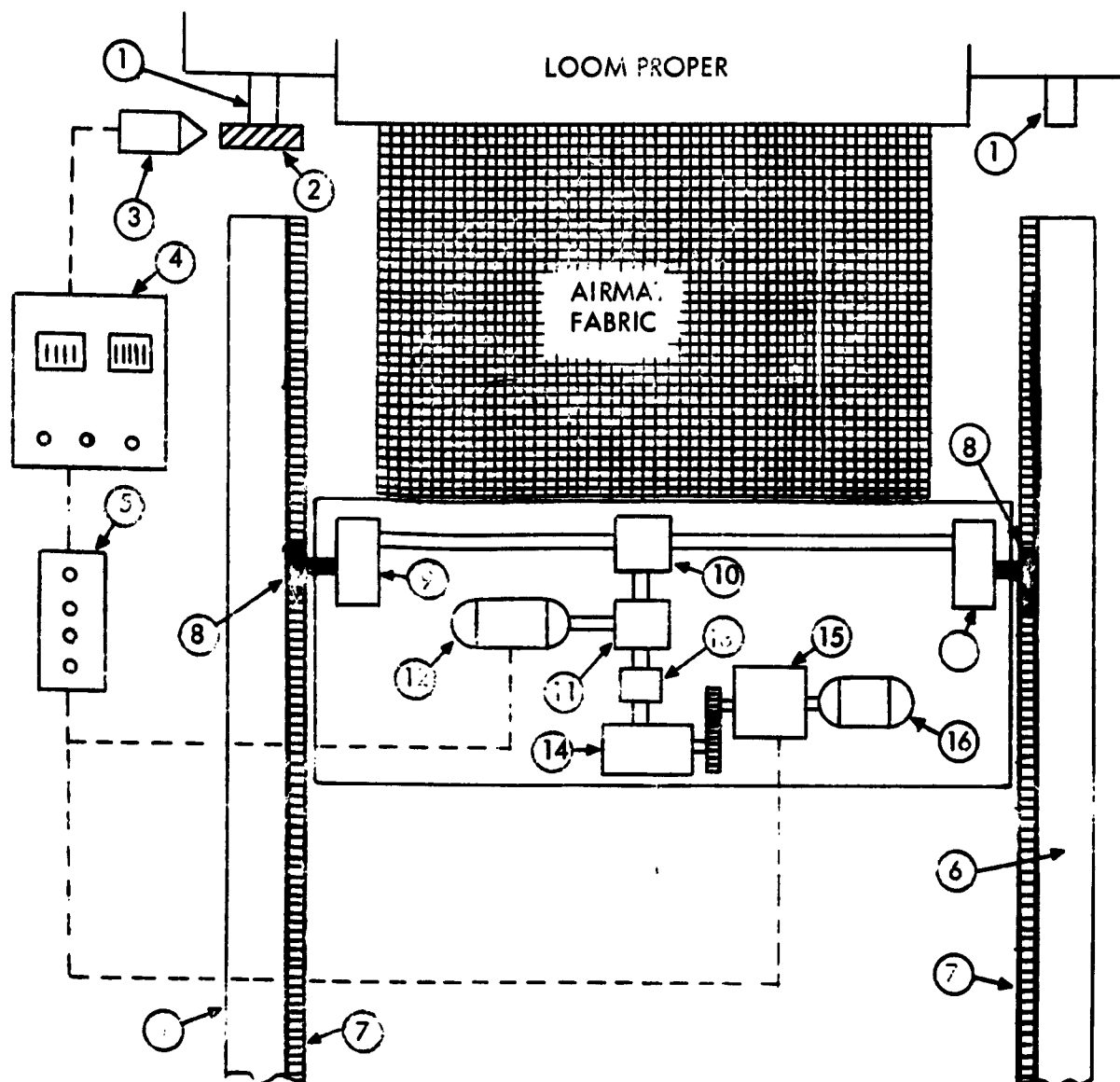


FIGURE 4
TAKE-OFF MECHANISM



- | | |
|------------------------------|---|
| 1. Loom Take-off Drive Shaft | 9. Gear Reducers 342-1 |
| 2. Stored Disc | 10. Gear Reducer 7 1/2-1 |
| 3. Detector | 11. Right Angle Drive 1-1 |
| 4. Electronic Counter | 12. Rapid Traverse Drive Motor 1 H.P. |
| 5. Control Station | 13. Electric Clutch |
| 6. Take-off Side Rails | 14. Gear Reducer 7 1/2-1 |
| 7. Stationary Drive Racks | 15. Single Revolution Index Clutch Unit |
| 8. Drive Pinions | 16. Gearhead Motor 1/3 H.P., 17 2/3-1 |

FIGURE 5

TAKE-OFF DRAW BAR DRIVE ELECTRONIC CONTROL

B. Program for Next Quarter - 1 January 1963 through 31 March 1963

The anticipated effort for the next quarter will cover the following items:

1. Loom Design and Fabrication

All of the manufacturing drawings will be completed. Procurement and fabrication of parts and subassemblies will continue. Assembly of the complete Structural Fabric Loom will be initiated.

2. Take-Off Mechanism

The design of the take-off mechanism will be completed and parts fabrication will be started.

3. Miscellaneous

GAC will continue to monitor Lansco's effort and will continue to study wire weaving techniques. A site will be chosen for loom installation at GAC and site preparation will be initiated. GAC will also order yarn and begin drawing in the warp.

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45	Defense Metals Info Center Battelle Memorial Institute Attn: Francis W. Boulger 505 King Avenue Columbus 1, Ohio	54	Massachusetts Institute of Technology Attn: Dr. S. Backer, Textile Division Cambridge, Massachusetts
46	Goodman Manufacturing Company Attn: K. W. Stalker, Mgr. of Engineering 48th and Halsted Chicago, Illinois	55	Mr. J. H. Ross Fibrous Materials Branch, ASRCNF Directorate of Materials and Processes Wright-Patterson AFB, Ohio
47	Aeronautical Systems Division Attn: ASRCE (Mr. Teres) Wright-Patterson AFB, Ohio	56	Leesona Moos Laboratories Div. Leesona Moos Corporation Attn: Dr. S. M. Chodosh 90-2B Van Wyck Expressway Jamaica 18, New York

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E. Bilsky and J. O. Miller 2. Textiles
17 January 1963 3. Metallic Cloth
pp. (Proj. 7-904) 4. AIRMAT*

(ASD TR 7-904 (VI)
(Contract AF33(600)-43036)

I. E. Bilsky
II. J. O. Miller
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IV. Contract AF 33(600)43036
V. ASD Project 7-904

The purpose of this program, as related to Aerospace applications, is to provide a means of manufacturing large low-density AIRMAT* structures, made of metallic cloth and yarns capable of small volume packaging.

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